Utilizing Controlled Vibrations in a Microgravity Environment to Understand and Promote Microstructural Homogeneity During Floating-Zone Crystal Growth

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Solidification processing with the floating-zone method is an established technique for growing semiconductor crystals. Advantages include a self-contained melt which minimizes the introduction of impurities and thermal stresses. Unfortunately, inherent to processing is the development of detrimental thermocapillary flow. Consequently, crystal quality should improve during float-zone processing if convective flow within the liquid volume is minimized. The objective, therefore, of this proposed experimental and theoretical investigation is to utilize vibration driven surface streaming flows in an effort to negate the effects of thermocapillary convection. A schematic representation of the experimental apparatus is shown in figure 121. The processing parameters will be evaluated with the intent of optimizing microstructural homogeneity.

The ground-based experimental and theoretical work will concentrate on defining the role various processing parameters play in promoting microstructural uniformity during floating-zone crystal growth. In particular float-zone dimensions, aspect ratios, oscillation frequency, and amplitude will be evaluated with the intent of understanding how thermocapillary flow is negated. To this end, work has already been initiated by utilizing the transparent sodium nitrate-barium nitrate model system, figures 122 and 123; further insight regarding crystal homogeneity will be gained by processing sodium nitrate crystals which have been doped with silver nitrate. This ground-based work would then be extended to the microgravity environment of space where the effect of thermocapillary flow on crystal homogeneity may be studied in an optimized floating-zone.

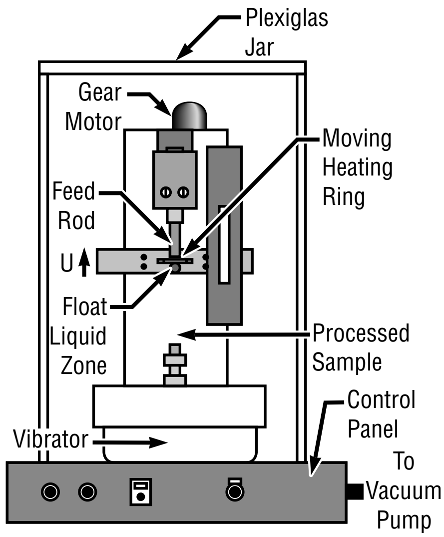

FIGURE 121.—Schematic representation of the experimental apparatus.

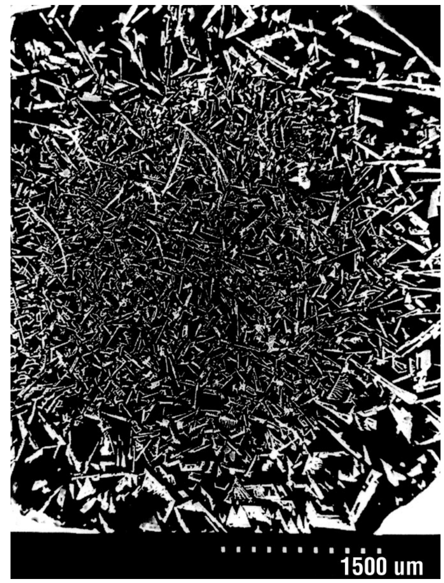

FIGURE 122.—Cross-sectional micrograph of a sodium nitrate-barium nitrate eutectic which has been float-zoned without vibration. Note non-uniformity between center and periphery.

Gravity driven flow which occurs during float-zone processing is minimized in a microgravity environment and thus permits thermocapillary flow to be singularly investigated. Here, utilizing incremented and calibrated vibration, the consequence of flow velocities on microstructure can be controlled and systematically investigated, not just acknowledged. The microgravity environment will minimize unit-gravity induced biases such as static shape distortion and buoyancy flow; furthermore, sedimentation of tracer particles will be minimized. Here then is an opportunity to evaluate crystal growth and homogeneity in association with a stable and dimensionally optimized floating-zone. The results of this study could well demonstrate a novel and inexpensive way of considerably improving crystal uniformity.

Shen, X.F.; Anilkumar, A.V.; Grugel, R.N.; Wang, T.G.:"Utilizing Vibration to Promote Microstructural Homogeneity During Floating-Zone Crystal Growth Processing." *Journal of Crystal Growth*, vol. 165, pp. 438–446, 1996.

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Biographical Sketch: Charles Baugher is a materials scientist and deputy division chief in the Microgravity Science and Applications Division of Space Sciences

FIGURE 123.—Cross-sectional micrograph of a sodium nitrate-barium nitrate eutectic which has been float-zoned with vibration. Note overall improvement in uniformity.

Laboratory. His recent research has been in the area of defining the low-level acceleration environment of the Space Shuttle during microgravity experimentation and in studying effects of that environment on materials processing. He has been published in the areas of electromagnetic propagation in plasmas, the interactions of plasmas with spacecraft, astronomical observations in the infrared, and the morphology of the Earth's magnetosphere.